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DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN MANEUVERABILITY

THIRD PARTIAL REPORT OF
USATECOM PROJECT NO. 8-3-7700-01, PHASE II
DEVELOPMENT OF METHODOLOGY FOR MEASURING EFFECTS OF PERSONAL CLOTHING AND EQUIPMENT ON COMBAT EFFECTIVENESS OF INDIVIDUAL SOLDIERS

JUNE 1965

U S ARMY
GENERAL EQUIPMENT TEST ACTIVITY
FORT LEE, VIRGINIA

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U.S. ARMY GENERAL EQUIPMENT TEST ACTIVITY
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DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN MANEUVERABILITY

Third Partial Report of
USATECOM PROJECT NO. 8-3-7700-01, PHASE II
Development of Methodology for Measuring Effects of
Personal Clothing and Equipment on Combat Effectiveness
of Individual Soldiers

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FOREWORD

This report reviews a portion of the work performed under Contract DA 19-129-QM-2068 (OI 6141) and is the third of a series of seven reports presenting the results of Phase II of the contract. (See Appendix D.) The project is a three-phase research effort directed toward the development of a field measurement methodology for evaluating the effects of Quartermaster clothing and protective equipment on the combat effectiveness of the individual soldier.

Earlier portions of the work accomplished under this project have indicated that a major constituent of the effectiveness of an individual infantryman in a combat situation is his level of performance in the individual physical tasks which are most important to battlefield success. A meaningful determination of the effect of clothing and personal equipment on the operating efficiency of an infantryman must therefore include objective measurements of his performance in these critical tasks. A survey of 208 highly qualified veterans of the four most recent operating theaters of the U.S. Army revealed that the ability to move and maneuver under enemy observation or fire was considered an important physical task by combat veterans. The task of maneuvering as an individual on the battlefield is assumed to require running, jumping, climbing and crawling, and this report describes the research performed to establish a reliable and sensitive method for measuring performance in these activities.

The work reported represents a joint effort by Dunlap and Associates, Inc. (D&A), and the Methods Engineering Directorate of the U.S. Army General Equipment Test Activity (GETA). The project team worked together closely throughout all activities but the major effort of D&A was in the development of the measurement schema, the design of the field trials, interpretation of the data and the preparation of the draft report. GETA prepared the test facilities, planned and conducted the field trials, collected and processed experimental data, and participated in its analysis.

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U.S. ARMY GENERAL EQUIPMENT TEST ACTIVITY
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DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN MANEUVERABILITY

Third Partial Report of
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June 1965

ABSTRACT

A three-phase research effort is underway to develop field methodology for measuring the effects of experimental clothing and equipment on the combat effectiveness of individual infantrymen. This report covers a portion of the work performed under Contract DA 19-129-QM-2068 (OI 6141) by Dunlap and Associates, Inc., and is the third of a series of seven reports presenting the results of Phase II of the study.

The first partial report in this series reported work performed to identify and rank the relative importance of the physical tasks performed in combat by the individual infantryman. One of the tasks considered by a sample of combat veterans to be important to combat success was the ability to move and maneuver while under observation or fire. This report describes the work performed to develop a reliable method for measuring soldier performance in the essential ingredients of this task under conditions considered representative of combat conditions. A proposed test course was established as a temporary facility and tested for reliability and sensitivity to differences in clothing and equipment using USAGETA Troops. It was determined that the events comprising the tested course provided a practical and useful basis for measuring the maneuverability of individual soldiers. A modified data collection system is recommended for an integrated field course to be evaluated as the next step in the research program.

DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN MANEUVERABILITY

I. Review of Research Objectives

The fundamental objective of the research effort was to develop, try out and evaluate a field performance course which measures an infantry soldier's ability to maneuver--to run, jump, climb and crawl as might be required when under enemy fire. The three main requirements which the course had to satisfy were:

- the test situation had to include a comprehensive sampling of those activities involved in individual maneuvering;
- the test situation had to be representative of the combat conditions under which individual infantrymen are required to perform these activities;
- the course operating procedures, instrumentation, and measures had to yield data which were sufficiently precise to indicate that the course would be sensitive to the effects of clothing and protective equipment on performance.[1,2]

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[1] The use of the word "sensitive" refers to the ability to detect small performance differences. A sensitive course presupposes reliability in the collection of measurement data.

[2] The validity of the present test situation and the performance measures to be obtained are logical (not statistical) validities. The validity of the combat task, as an important aspect of the criterion, is considered to be demonstrated by the independent judgments of combat veterans (see results from the Further Refinement of Important Combat Tasks). The validity of the test situation in which task performance is being measured must be either accepted or rejected on logical grounds. Either the test setting does or does not represent the essential features of the conditions under which a man will be required to maneuver when under enemy fire. The validity of the measures must also be accepted or rejected on the basis of logic. That is, the measures either are or are not measures which reflect performance associated with maneuvering.

Other features, deriving in part from the foregoing, which the course was to satisfy included:

- separate measurement and evaluation of each of the subactivities involved in maneuver had to be permitted;
- rapid movement through the course was required.

The latter requirement of rapid movement through the course was considered desirable for the following two reasons. First, since the Maneuver Course was to be integrated eventually with other performance courses, efficiency in the use made of testing time was necessary for all courses. Second and more important, the most practical scheme for controlling delays between course events--while allowing for separate measures in the subactivities--was to virtually eliminate such delays.

II. Essentials of Test Course as Originally Proposed

The measurement situation originally proposed for research purposes was a course consisting of the following five events:

a) A 100-yard dash simulating the need to traverse an open area. The event was to be broken down into two 50-yard dashes. A test subject was to start from a prone position and run, as rapidly as possible, 50 yards to a designated position which afforded cover. Upon reaching the covered position, the subject was to drop quickly to the prone position and put his rifle to his shoulder. Performance in each 50-yard segment was to be measured separately.

b) A 25-foot rope ladder simulating a debarkation net or the requirement to hastily climb and descend obstacles using ropes.

c) A 100-yard obstacle course simulating the need to run in a broken or zig-zag fashion, avoid obstructions, and scale moderate obstacles. This event was to require a test subject to change direction while running, scale or climb through several obstacles representing low walls and the window of a building, and jump across/into an open pit. The open pit jump was to occur at the end of the course, and the distance jumped was to be measured as a separate aspect of performance.

d) A 25-foot overhead ladder simulating the need to traverse an open area using the hands and arms alone in a hand-over-hand fashion.

e) A 50 to 75-yard crawl simulating the need to traverse an area by crawling under barbed ware and over/through other low obstacles affording protection from enemy fire.

The foregoing events were to be arranged physically such that the termination of one event also constituted the starting point for the next event. Procedurally, subjects were to traverse the course as individuals and in a staggered starting sequence. Waiting time between events was to be kept to a minimum. A Senior Controller, located at the beginning of the course, was to schedule the starting of test subjects. Observer/Recorders (O/R's) were to be located at the end of each event to record performance and start a subject onto the next event.

III. Description of Actual Test Setting

The test course which was evaluated during Phase II was virtually identical to that described above. The departures worthy of note were:

a) The open pit jump was made a separate event, instead of having it integral with the obstacle course.

b) The overhead ladder was shortened to 17 feet, in lieu of the originally proposed 25 feet.

c) A 20-foot debarkation net was used, instead of the 25-foot rope ladder.

d) The length of the obstacle course was increased from 100 to 200 yards.

The reasons for these changes were as follows. The open pit jump was made a separate event in order not to confound the time associated with the running jump with the time required to traverse the obstacle course. The separation of the two events permitted for a somewhat "cleaner" measurement of both the elapsed time to perform the obstacle course activities and also the distance jumped.

All of the remaining changes (the shortening of the overhead ladder, the 20-foot debarkation net, the increased length of the obstacle course) were occasioned by the decision to adapt a portion of one of the existing accelerated fabric wear courses at Ft. Lee for use as the Maneuver Course. Since the accelerated wear course already contained several of the desired events, it was economical both in terms of construction costs and preparation time to use the existing facilities. The accelerated wear course contained the 17-foot overhead ladder, a 20-foot tower with debarkation nets hung on two sides, and several obstacles which could be used in the obstacle course event. Moreover, in addition to the aforementioned savings, it was felt that the Maneuver Course concept and potential sensitivity could adequately be evaluated by use of the existing facilities.

Figure 1 shows in plan view the actual layout of the experimental test course. Insofar as possible, the termination of each event was also the starting point for the next event. The order of events (as shown in Figure 1) was as follows:

- First, the two 50-yard dashes.
- Second, the obstacle course.
- Third, the overhead ladder.
- Fourth, the running jump.
- Fifth, the 20-foot debarkation nets.
- Sixth, the crawl course.

The crawl course was purposely sequenced as the last event because of the high degree of physical exertion which it demanded. It was our original concern that the physical demands of the crawling might affect a subject's motivation and thus the degree of effort made in performing the subsequent events. While there was no evidence for this concern, it seemed a safer alternative to leave the crawling for last.

Figure 2 shows equipment being adjusted on a subject before he starts the course. Figures 3 through 24 show each of the separate events. The start of the course was marked by a log. The end of each of the two 50-yard dashes, the end of the obstacle course event, and the end of the crawl course were all marked by sandbags arranged as a firing position. The end of the first 50-yard dash served as the starting position for the second 50-yard dash, and the end of the second 50-yard dash served as the starting position for the obstacle course. Relatively short distances separated the remaining events as follows:

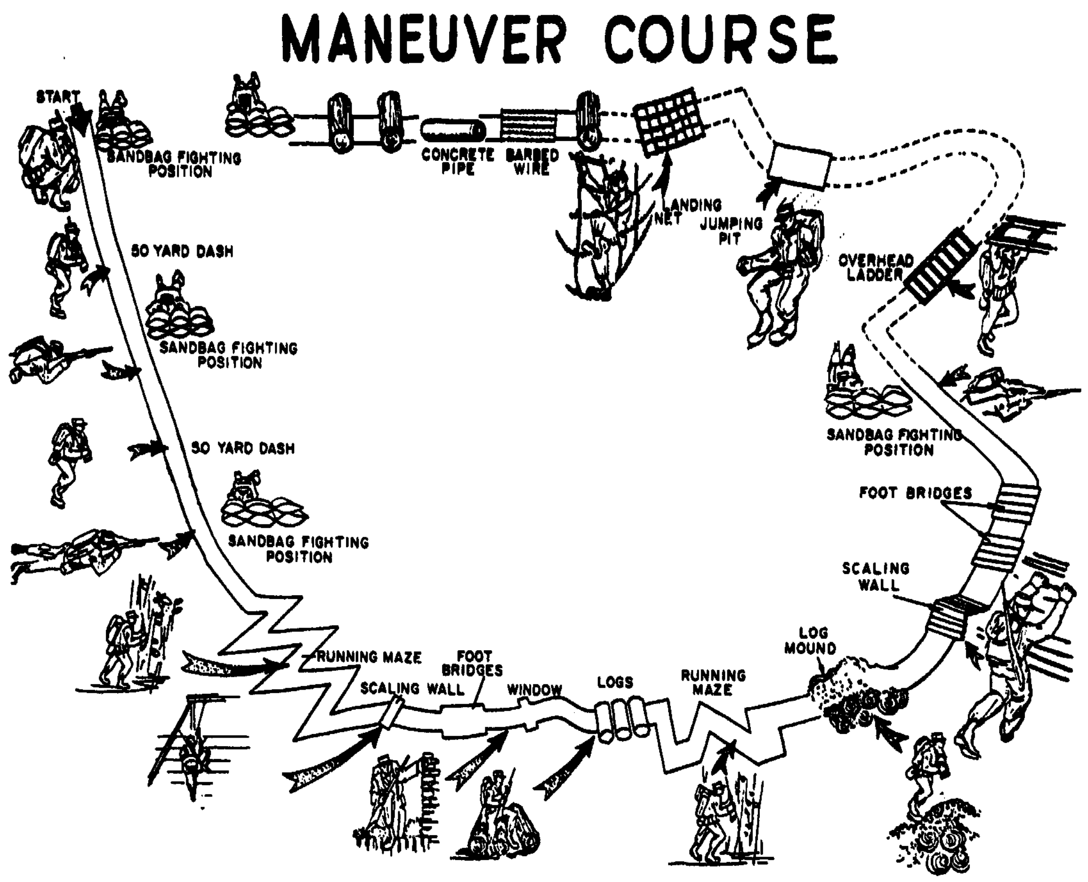

Figure 1. Maneuver Course: Plan View

Figure 2. Maneuver Course: Adjusting Equipment Before Starting.

Figure 3. Fifty-Yard Dash: Starting Position, Subject Prone.

Figure 4. Fifty-Yard Dash: Subject Running.

Figure 5. Fifty-Yard Dash: Subject Completing Dash Event.

Figure 6. Fifty-Yard Dash: Event Completed and Ready for Next Event.

Figure 7. Obstacle Course: Subject Running the Maze.

Figure 8. Obstacle Course: Subject Climbing First Scaling Wall.

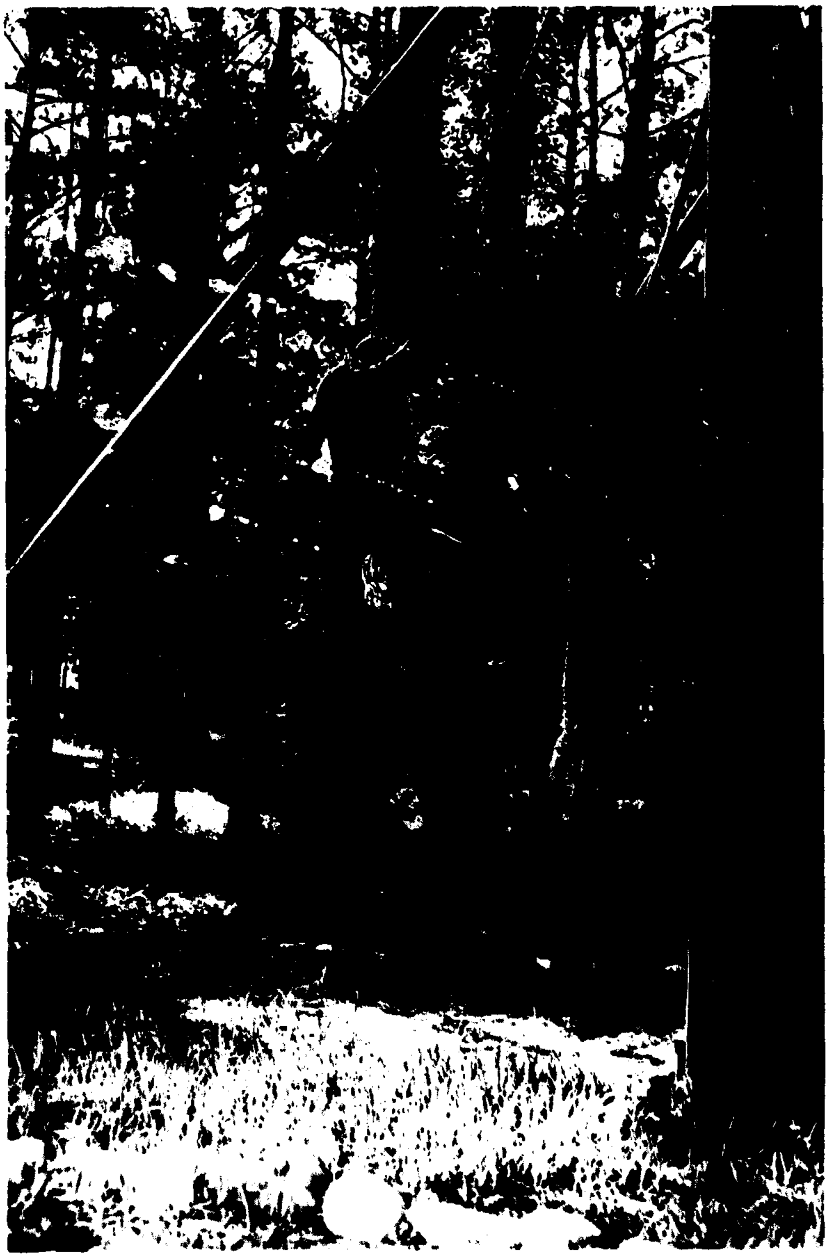

Figure 9. Obstacle Course: Subject Descending First Scaling Wall.

Figure 10. Obstacle Course: Subject Crossing First Foot Bridge.

Figure 11. Obstacle Course: Subject Climbing Through Window-Sized Obstacle.

Figure 12. Obstacle Course: Subject Running Over Ground Logs.

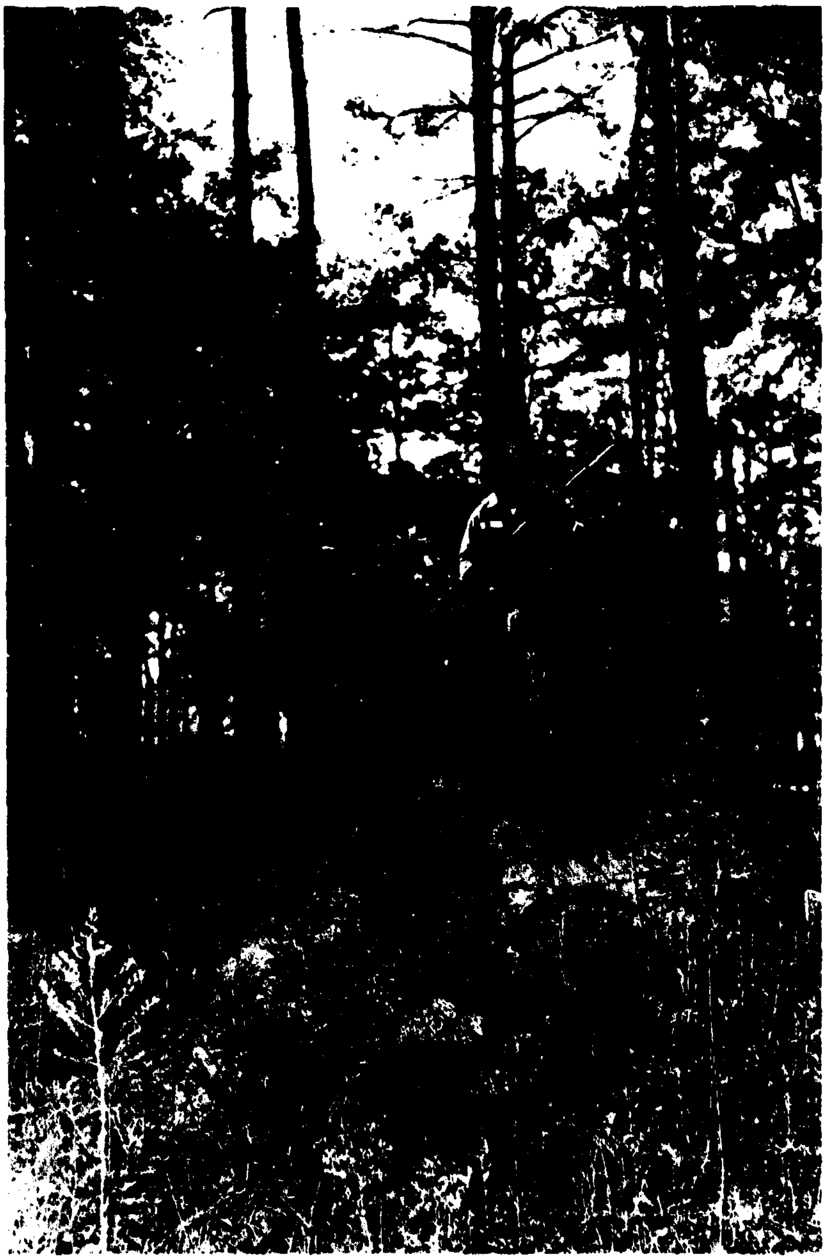

Figure 13. Obstacle Course: Subject Traversing Dirt and Log Mound.

Figure 14. Obstacle Course: Subject Climbing A-Frame Scaling Wall.

Figure 15. Overhead Ladder: Subject Traversing Ladder.

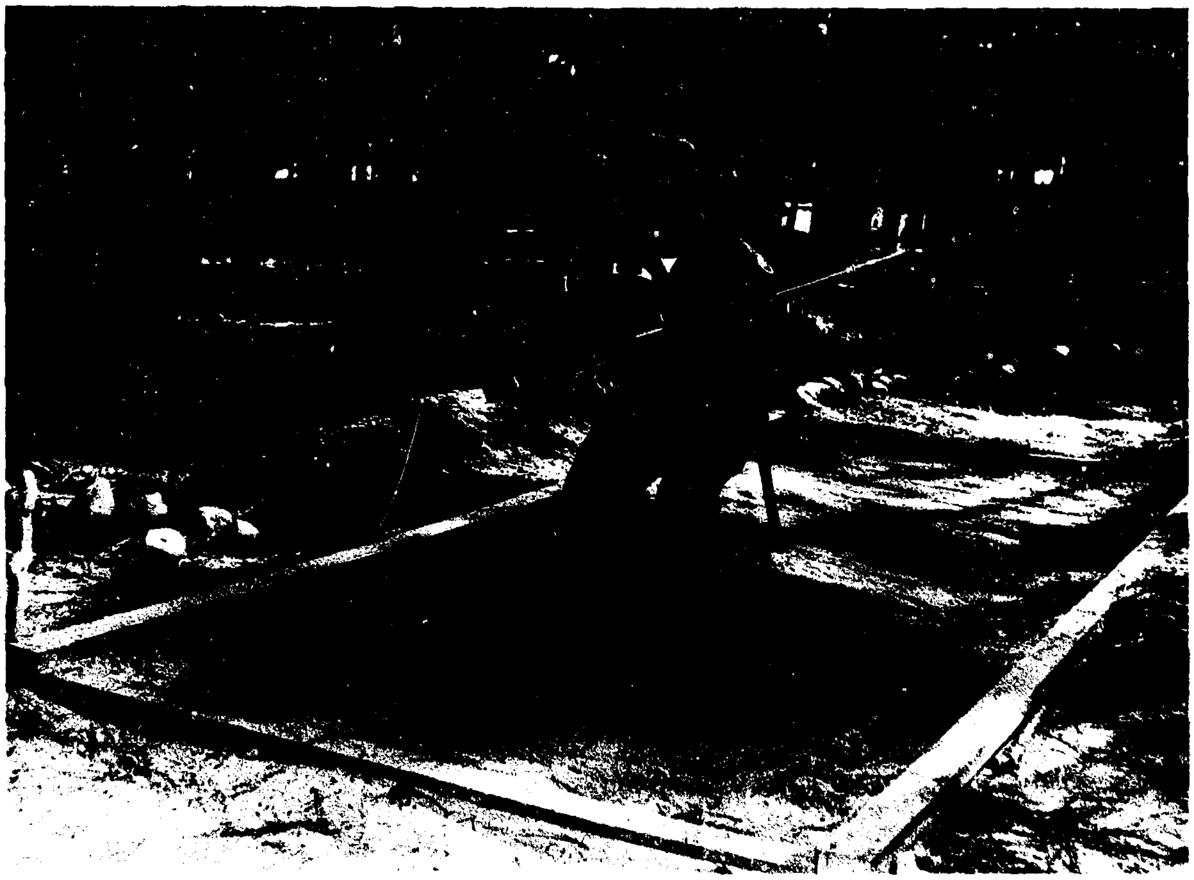

Figure 16. Running Jump: Subject Landing in Sand Pit.

Figure 17. Running Jump: O/R Measuring and Recording Length of Jump.

Figure 18. Debarkation Tower and Nets: Subject Climbing.

Figure 19. Debarkation Tower and Nets: Subject Descending.

Figure 20. Crawl Course: Subject Approaching Barbed Wire Obstacle.

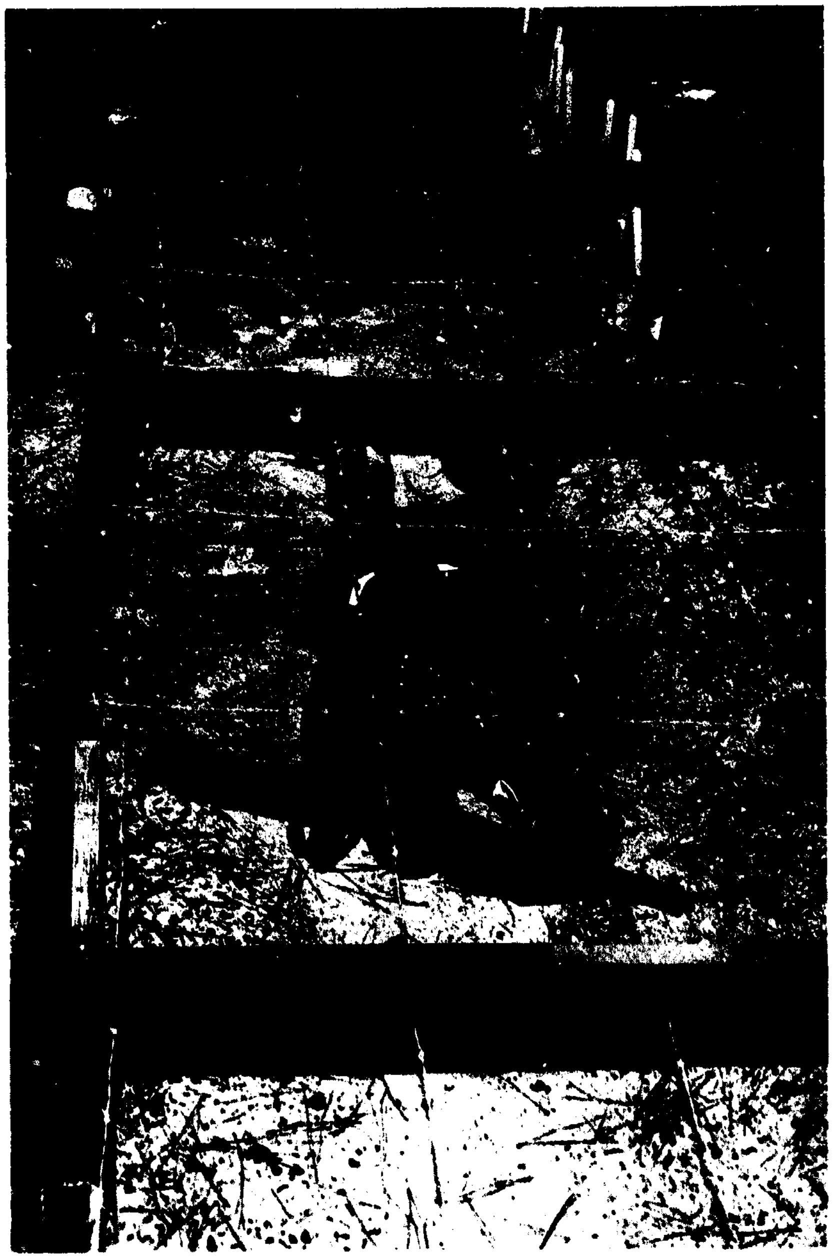

Figure 21. Crawl Course: Barbed Wire Obstacle (Top View).

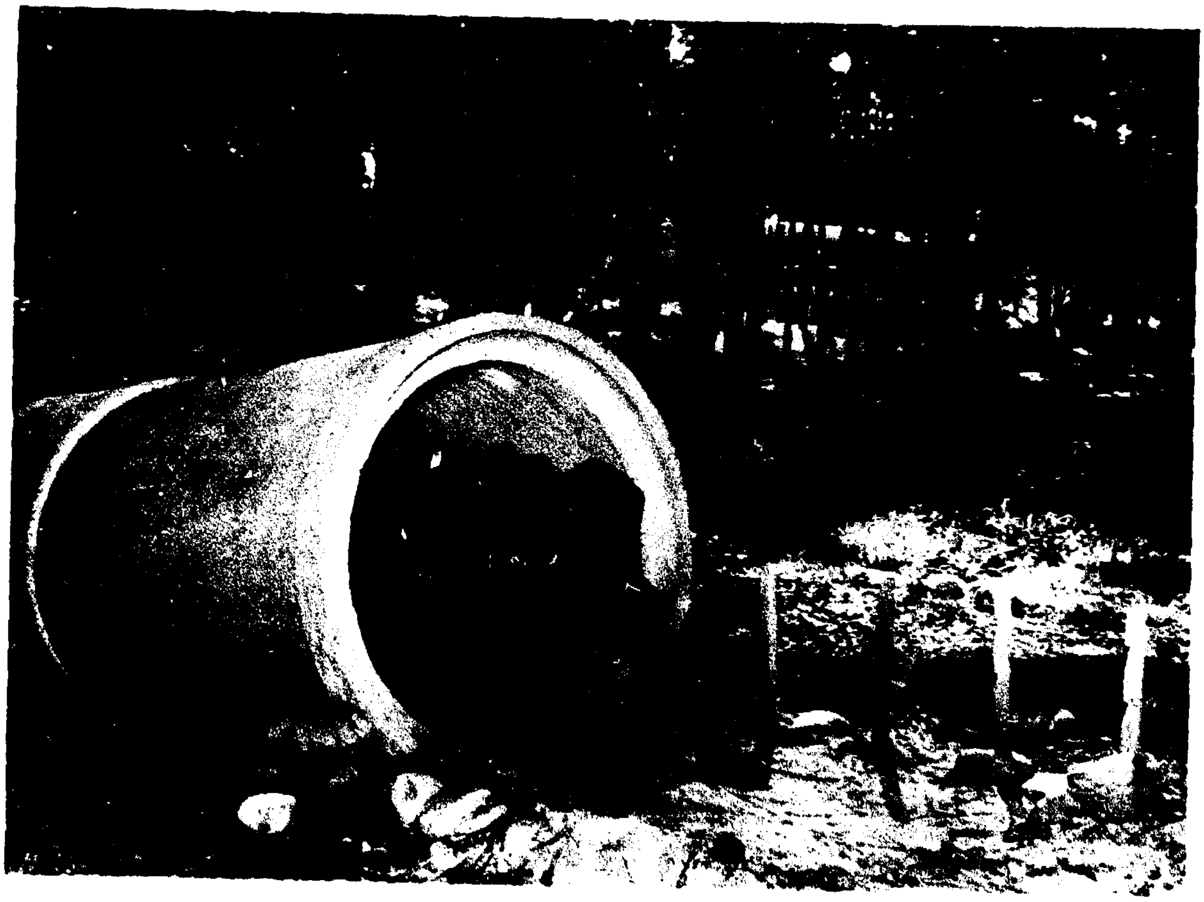

Figure 22. Crawl Course: Concrete Pipe Obstacle.

Figure 23. Crawl Course: Subject Completing Low Crawl Over Log.

Figure 24. Crawl Course: Finish Line.

- Between the obstacle course and the overhead ladder--10 feet.
- Between the overhead ladder and the jump event--75 feet.
- Between the jump event and the debarkation nets--56 feet.
- Between the debarkation nets and the crawl course--120 feet.

As shown in Figures 1, and 7 through 14, the obstacle course consisted of a running maze, a 13-foot wall to be scaled, a foot bridge 15 feet long and 2 feet wide, a window-sized obstacle through which subjects had to climb, a ground obstacle consisting of four logs with approximately 18 inches between each log, another running maze, a mound of logs and earth 22 feet long and 5 feet high, another scaling wall 11 feet high, and two more foot bridges each of which was 6 feet long and 2 feet wide. As may be seen in Figures 8 and 9, the first scaling wall required subjects to use hand and foot lugs to ascend the wall; they then lowered themselves first to a platform (8-1/2 feet from the ground) and then to the ground with the aid of a rope. The window-sized obstacle (see Figure 11) was positioned 3 feet from the ground, and the opening was 2-1/2 feet wide and 3 feet tall. The second scaling wall (see Figure 14) was in the shape of an "A" frame; it had horizontal "rungs" extending 1-3/8 inches above the surface and positioned every 9 inches. Subjects were instructed that this obstacle could best be scaled by positioning the feet parallel to the rungs (a sort of side-stepping motion).

The overhead ladder (see Figure 15) consisted of eight (8) rungs with 2 feet between each rung. There was approximately a 2-foot reach from the starting position to the first rung, and the ladder was 8-1/2 feet above the ground.

The sand pit (see Figure 16) into which subjects jumped for the running jump event was 16 feet long and 6-3/4 feet wide. The starting line for this event was 32 feet from the "jump line"; the latter was marked by a length of pipe, painted yellow and buried to be flush with the ground.

The debarkation nets (see Figures 18 and 19) were hung from a tower 10-1/2 feet wide. After ascending one net, a subject walked to the opposite side of the tower and then descended using the other net.

The crawl course (see Figures 20 through 24) was 70 yards long. It contained first a barbed wire obstacle (20 feet long and 6 feet wide) which required a "low" or belly crawl, then a concrete pipe (3 feet in

diameter and 12 feet long) through which a subject crawled using the "high" crawl (hands and knees), then another barbed wire obstacle (25 feet long and 6 feet wide) requiring the low crawl, then a log at which subjects were required to turn parallel and roll over, then another barbed wire obstacle (30 feet long and 6 feet wide), and finally another log. The barbed wire obstacles were all at a height of 2 feet from the ground. The distances between the obstacles on the crawl course were as follows:

- Start to First Barbed Wire Obstacle--11 feet.
- First Barbed Wire Obstacle to Concrete Pipe--22 feet.
- Concrete Pipe to Second Barbed Wire Obstacle--11 feet.
- Second Barbed Wire Obstacle to First Log--19 feet.
- First Log to Third Barbed Wire Obstacle--24 feet.
- Third Barbed Wire Obstacle to Second Log--11 feet.
- Second Log to Finish--18 feet.

IV. Course Operating Procedures

Operation of the course was controlled by a Senior Controller who was normally located at the start of the course. The main features of the operating procedure were as follows.

Initially, on their first exposure to the course, test subjects were read a set of standard instructions (see Appendix A). The standard instructions indicated the purpose of the course and how each subject was to proceed. After this briefing and the answering of any questions, the test subjects were walked through the course. While walking through the course, the instructions concerning how subjects were to proceed were reviewed again. On the obstacle course, an O/R demonstrated the negotiation of the scaling wall, the window-sized obstacle, and the A-frame obstacle.

After the foregoing familiarization, each test subject individually performed on the course. While the starting of subjects was staggered, there were never more than two subjects on the course at the same time. The Senior Controller was responsible for starting each subject and for ensuring that no subject was delayed on the course by a preceding subject. Since the longest times and the largest individual variations (in absolute time) occurred on the crawl course (event number six), the Senior Controller normally started the next test subject when the subject already on the course had arrived at the debarkation net (event number five).

Each subject started the course from a prone position behind a log which marked the beginning of the course. On signal from the Senior Controller, a test subject arose, ran the first 50-yard dash, and then took a prone firing position (with his rifle at his shoulder) at the sandbags which marked the end of the first dash. Thereafter, the movement of a subject was directed by an O/R located at the end of each event. For example, the O/R at the end of the first 50-yard dash signaled the subject when to "GO" on the second 50-yard dash. The O/R at the end of the second 50-yard dash, in turn, started the subject on the obstacle course event.

The duties of test personnel were also explained initially using prepared instructions. A sample of the basic O/R Briefing is given in Appendix A. The duties and assignments were as follows.

The Senior Controller, as already explained, was responsible for overall operation of the course. In particular, he sequenced the starting of subjects. There were seven O/R's, one stationed at the end of each event, whose duties were essentially similar. Each O/R stopped a time clock (with the exception of the O/R at the jump event) when the subject completed the particular event. He subsequently recorded the elapsed time (or distance jumped, in the case of the jump event), insured that the O/R at the end of the next event was ready, and then simultaneously started both the subject and the time clock for the next event. After a subject had been started on the next event, an O/R reset his own clock and prepared for the next subject. (The use of the time clocks and their arrangement is discussed in the next section.)

V. Instrumentation

The instrumentation used in measuring performance consisted of: six A. W. Haydon K15120 laboratory stop clocks; six boxes each containing a latching relay plus receptacles providing power to and control of the clocks; twelve microswitches, positioned in aluminum tubular stock, which served as remote control switches for the clocks; and wiring to connect the control switches to their respective clocks and to provide power to the relay boxes.

The Haydon clock displayed time to within 10 milliseconds (1/100 of a second). It had a clock face dial with two hands (see Figure 25). The smaller or inner hand accumulated in seconds up to a total of 60 seconds. In addition to an electric reset capability, the clock could

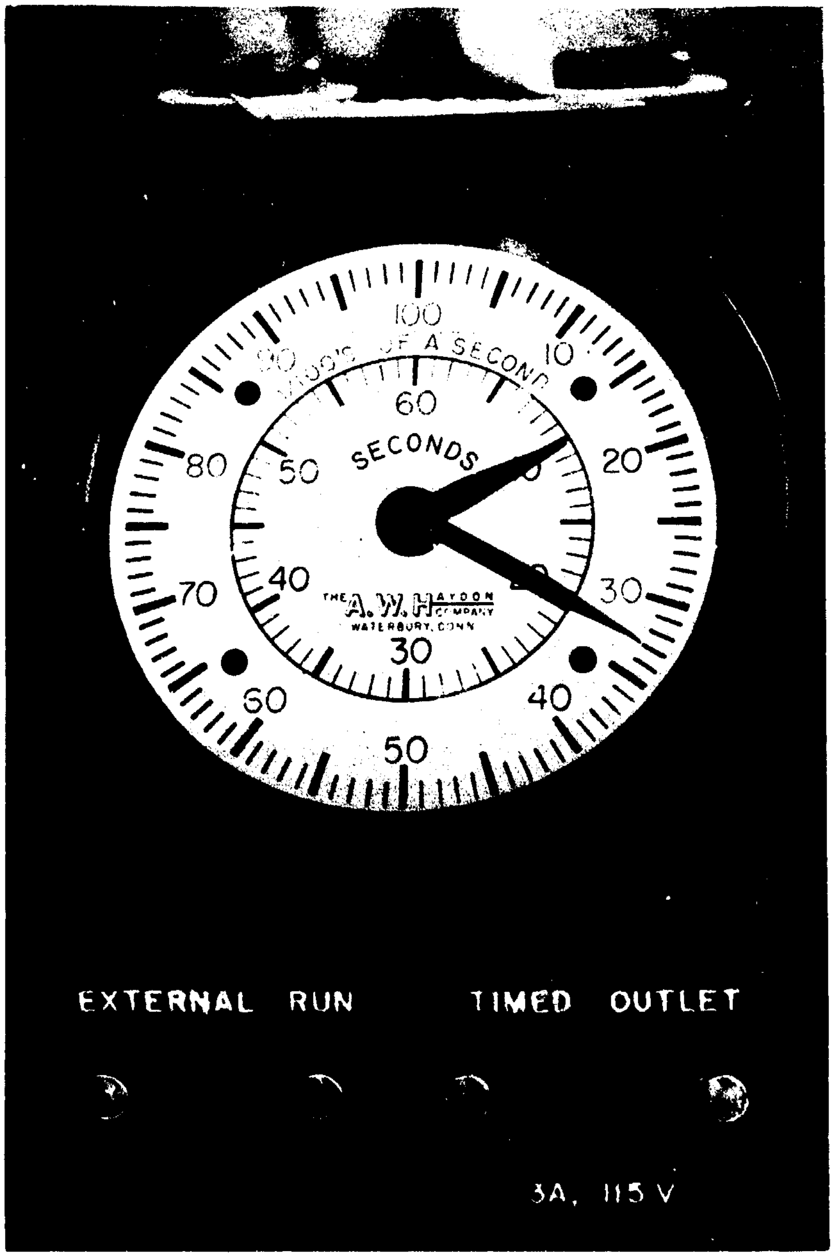

Figure 25. Instrumentation: A. W. Haydon Stop Clock.

be operated by either remote controls or by the two push-button switches on the top of the clock housing.

The latching relay associated with each clock caused a clock, once started, to continue to run until a signal de-energized the relay by breaking the "latch." It was thus possible for the O/R at the beginning of each event to remotely start the time clock for that event. The clock would then continue to run until the O/R at the end of the event depressed his control switch (and unlatched the relay). For each event, the time clock and associated relay box were located at the end of the event, which enabled the O/R stationed at the end of the event to record the time and then (after starting the subject on the next event) to reset the clock using the reset button on the top of the clock housing.

A more detailed description of the instrumentation operation with wiring and pictorial diagrams is presented in Appendix B.[1]

VI. Measures and Test Design

A. Measures

With the instrumentation arranged as described in the preceding section, data were collected on the following basic measures:

- Time (.01 of a second) to perform each event (except the jump event).

- Distance in feet and inches jumped for the jump event.

- Number of rungs completed on the overhead ladder (if event not completed). (Time to traverse the ladder was the primary measure for subjects completing the event.)

[1] It should also be mentioned that initial trials with the course used a single stop clock and several PRC-6 radios. In order to save testing time while awaiting delivery of the A. W. Haydon clocks, one clock (loaned by the manufacturer) was located centrally and voice commands via the PRC-6's were used as signals to start and stop the clock. This procedure was less than desirable because it introduced the response time variation of still another person--the man controlling the single clock--into the data. However, the procedure did allow us to make a start at evaluating the course. All data collected using this method have been so indicated in Section VII.

B. Test Design

The experimental testing was designed to provide information on the following points of interest:

- The feasibility and suitability of the course concept and operating procedures.
- The suitability of the instrumentation concept and equipment.
- The reliability and potential sensitivity of the course.

The reliability of a given test course refers to the precision and accuracy of measurement which the course provides. It can be evaluated in terms of the consistency (i.e., repeatability) of the experimental results obtained from the course over some time period. A measure of reliability, of course, will be obtained from the Phase III testing. However, it appears possible to infer something about course reliability from Phase II results. If a statistically significant difference (at, say, the 5% level of confidence) is obtained between performance measures for a treatment condition (e.g., different combat pack weights), one infers that the obtained difference is not likely to occur by chance. A significant performance difference suggests that, if the test were to be repeated under the same conditions (e.g., with the same treatment conditions, the same procedures, and the same subject population), one might expect to obtain similar results. Thus one can estimate that a course is reasonably reliable if statistically significant performance differences occur. This is the best estimate that can be made on the basis of Phase II results.

The sensitivity of a test course is evaluated in terms of whether the course is able to detect a real performance difference if one exists. If a test course reveals statistically significant differences between performance measures for a treatment condition, then the course can be considered sensitive. Sensitivity and reliability of a test course are interrelated. Accurate and precise measurement will lead to a small within treatment (error) variance. The smaller the within treatment variance, the smaller are the performance differences between treatments that are needed to produce statistical significance. Thus if a test course produces statistically significant performance differences for a treatment condition, it can be assumed to be sensitive and at least minimally reliable.

The Maneuver Course was evaluated in two repeated measurement test designs in which various weights distributed about the M56 combat pack and harness and the armored vest (Armor, Body, Fragmentation Protective, stock numbers 8470-261-6635, 6636, 6637) were the independent variables or treatment conditions. The designs are illustrated in Figure 26.

The rationale underlying the use of these test designs was as follows. If the course is composed of the same maneuver activities as are required in combat, and if the conditions under which these activities are performed are representative of the combat setting, then the performance data obtained from the course are a valid indication of performance to be expected under combat conditions. Thus, if one finds no significant differences among the performance measures, one might conclude that no differences will exist among the particular clothing and/or equipment items studied in the actual combat setting. It is possible, of course, that uncontrollable sources of variation may be masking small but real performance differences which will become apparent only with a more refined Phase III version of the course. However, the development of this Phase III course is better justified if it can be shown in Phase II that the course will detect real differences if they exist. It is obvious, of course, that a field performance course which fails to differentiate between the clothing and equipment which it was designed to evaluate is of little potential utility to the Army. It was our hope in selecting treatment conditions (Armored Vest vs. No Armored Vest, and differential weights distributed about the M56 pack) for this Phase II course that some performance differences would occur. It was also our hope in designing the measurement system that the data obtained would be sufficiently accurate and precise to detect real performance differences if they exist.

Several other points should be mentioned with regard to the foregoing test designs. First, the repeated measurements were used in order to provide sensitivity with respect to the primary independent variables. Second, in implementing the designs, the order in which subjects performed under the various treatment conditions was counterbalanced. The counterbalancing was used to offset any effects that might attend the order of testing. In implementing the counterbalancing, subjects were tested on adjacent days (under the appropriate condition)--to the extent possible. A test subject performed on the Maneuver Course only once on any given test day.

Event	Subjects	Performance (Time in Seconds)		
		10# Pack	25# Pack	40# Pack
1st 50-Yard Dash	Subject 1 Subject 2 . . . Subject n			
2nd 50-Yard Dash	Subject 1 Subject 2 . . . Subject n			
Obstacle Course	Subject 1 . . . Subject n			
Overhead Ladder	Subject 1 . . . Subject n			
Debarkation Net	Subject 1 . . . Subject n			
Crawl Course	Subject 1 . . . Subject n			
Running Jump	Subject 1 . . . Subject n	(Distance Jumped in Feet & Inches)		

Figure 26. Test Designs.

Event	Subjects	Performance (Time in Seconds)	
		With Vest	Without Vest
1st 50-Yard Dash	Subject 1 Subject 2 . . Subject n		
2nd 50-Yard Dash	Subject 1 Subject 2 . . . Subject n		
Obstacle Course	Subject 1 . . . Subject n		
Overhead Ladder	Subject 1 . . . Subject n		
Debarkation Net	Subject 1 . . . Subject n		
Crawl Course	Subject 1 . . . Subject n		
Running Jump	Subject 1 . . . Subject n	(Distance	Jumped)

Figure 26. Test Designs
(Continued)

VII. Results

The data to be presented cover testing sessions which span the period of 19 August 1963 through 21 April 1964. All of the data pertain to Quartermaster test subjects. The data are broken out into three sets of results: 1) Testing with the Armored Vest; 2) Testing with the Weighted Combat Packs; and 3) Additional Testing with the Weighted Combat Packs. As will be discussed subsequently, the additional testing with the combat packs was undertaken in the light of the first set of results obtained with the packs.

A. Testing with the Armored Vest[1]

The data for the Vest vs. No Vest comparison were collected during the period 19-29 August 1963. These were the first data obtained from the course, and subject performance was measured using the provisional instrumentation previously described. While the size of the sample of data for each event is small, and even though provisional instrumentation was used to collect the data, it seems desirable to make these results a matter of record.

Table 1 presents the results obtained under the Vest vs. No Vest conditions for each event. Presented in Table 1 are the size of the sample, the average performance under the indicated conditions, and the results of statistical tests for differences between conditions. In making the statistical tests, a one-tailed t-test based on the differences between the related data from each subject was used.[2] The one-tailed test is the proper one under our hypothesis that, if a difference occurred, it would be in the direction of a decrease in performance with the vest.

With regard to Table 1, it should be mentioned that the results shown are based upon averaging the results from three or four replications of the course for each subject under each condition. (The replicated data were obtained in counterbalanced order under each condition for each subject, as mentioned earlier.) Some subjects were not

[1] The weight of the armored vest varies as a function of size: small--10.2 lbs.; medium--11.0 lbs. (estimated); and large--11.6 lbs. All three sizes are represented in the sample.

[2] See Walker, Helen M. & Lev, J. Statistical Inference. Holt, New York, 1953, pp. 151-154 concerning the mean of a population of differences between two measures for each subject.

Table 1. Comparison of Vest vs. No Vest

Data of 19-29 August 1963[1]

Early Data Using PRC-6 Radios and a Central Clock

Course Event	N	Average Performance (Secs.)		Test for Significant Differences
		Vest	No Vest	
1st 50-Yard Dash	8	11.7	11.0	N.S.
2nd 50-Yard Dash	8	14.0	13.8	N.S.
Obstacle Course	7	111.9	122.4	N.S.
Overhead Ladder	4	6.2	5.6	No Test
Landing Net	7	48.2	43.6	*
Crawl Course	6	195.5	202.0	N.S.
Running Jump (Ft.)	7	10.9	11.4	N.S.

* = Statistically Significant Difference, $p < .05$

[1] Performance for each subject determined by averaging over three or four replications of course under each test condition.

available for one or another testing session. Since the sample was already small, a further reduction in the number of subjects was undesirable. We therefore chose to estimate performance based upon three replications for those subjects who had missed one session. (Subjects who missed more than one replication were eliminated from consideration in preparing Table 1. The results for each individual replication of the Vest vs. No Vest comparison are presented in Appendix C, Table 4.)

As may be seen in Table 1, a significant performance effect was detected in the landing net event, and no significant performance effects were detected in the other events. In fact, on the obstacle and crawl courses, average times were less with the vest than without. No statistical analysis was performed on data for the overhead ladder event because of the small number of subjects who completed at least three replications on this event.

As stated previously, these data are reported here as a matter of record only since they were obtained with preliminary instrumentation. It was hoped that some trends would be indicated by the data. Results, however, were generally inconclusive.

B. Testing with the Weighted Combat Packs

The data for the comparison of the three weighted packs were obtained during 4-6 September 1963. The primary instrumentation of individual stop clocks at each event was used. A counterbalanced testing sequence was used to protect against any systematic effect that might attend the order in which subjects performed with the three weighted packs. Subjects performed on the course only once on any given day. The packs themselves, as indicated in Table 2, were of 10, 25, or 40 pounds total weight. These weights were distributed about the pack and harness in accordance with the manner with which the M56 load-carrying system was designed to be used. The indicated weight of the packs, as already mentioned, was a total weight which included the pack itself, the harness, two cartridge cases, a full canteen, and the entrenching tool.

The average performance obtained under each pack for each event is presented in Table 2. Also given are the results from statistical tests of the differences among the weighted packs. An analysis of variance was performed on these data. If a significant

Table 2. Comparison of Weighted Combat Packs

Data of 4-6 September 1963; N= 9

Course Event	Average Performance (Seconds)			Result of Significance Tests[a]
	10# Pack	25# Pack	40# Pack	
1st 50-Yard Dash	17.5	16.8	17.8	No Significant Differences
2nd 50-Yard Dash	18.9	22.5	21.8	No Significant Differences
Obstacle Course	155	182	194	Significantly longer time required with 40# Pack than with 10# Pack
Overhead Ladder[b] (N=3)	6.1	7.3	8.9	No Test Run (See Note b)
Landing Net	45.6	64.8	72.1	Significantly longer time required with 25# and 40# Packs than with 10# Packs
Crawl Course	199	231	305	Significantly longer time required with 40# Pack than with 10# or 25# Pack
Running Jump	9.4ft.	7.7ft.	6.9ft.	Significantly longer distance jumped with 10# Pack than with 25# or 40# Packs

[a] At the 5% level of significance.

[b] As weight increased, fewer men completed event; i.e., 8, 6, and 3 men completed event with 10#, 25#, and 40# Packs, respectively.

F-value was obtained, averages were separated by Duncan's technique.[1]

As shown in Table 2, significant performance differences were detected in the obstacle course event, the landing net event, the crawl course event, and the running jump event. In these four events, performance times were significantly longer for the 40-pound pack than for the 10-pound pack. For the landing net and running jump events, performance times were significantly longer for the 25-pound pack than for the 10-pound pack. For the crawl course event, performance times were significantly longer for the 40-pound pack than for the 25-pound pack. No other significant differences were found.

The results for the overhead ladder event (see Table 2, and Note b below the table), are in the expected direction; however, since only three subjects were able to complete the event with the heaviest pack, a statistical test of the time required to complete the event was not performed. The time data that were available are in the expected direction, and combined with the increasing inability of people to complete the event as their load increased, the expectation is that the event is discriminating.

With regard to the two 50-yard dashes, no significant performance effects were associated with the differential pack weights. It may be noticed, in Table 2, that the differences among the packs were more pronounced for the second 50-yard dash than for the first 50-yard dash.

C. Additional Testing with the Weighted Combat Packs

After the results shown in Table 2 were available, we were concerned about the relative insensitivity of the two 50-yard dash events. In discussing the results in the light of this concern, it was noticed (as mentioned above) that the magnitude of performance differences was greater in the second of the two 50-yard dashes. This suggested that possibly the dash events could be made more discriminating if they were again repeated after a subject had completed the six events which already comprised the experimental Maneuver Course. The thinking was that possibly the original two dash events were serving as

[1]Duncan, D. B. Multiple range and multiple F-tests. Biometrics, 1955, 11, 1-42.

prestressors and thereby contributing to the performance effects being discriminated in the subsequent course events. If this were so, the cumulative effects of the entire course might serve as a prestressing condition such that the dashes, if repeated at the end of the course, would be discriminating.

It was thus decided to evaluate the performance effects associated with a repetition of the two 50-yard dashes following the six events of the experimental Maneuver Course. The data were collected during 1-2 and 13-21 April 1964. At the time, we were also collecting performance data on the March/Move Course. The Maneuver Course with the two extra dashes was always performed first--before a test subject performed on the March/Move Course. Performance data were collected separately for each dash event; a combined time score was obtained for all of the other Maneuver Course events. The latter was occasioned by the fact that we were operating two courses simultaneously (subjects proceeded directly to the March/Move Course) and there was not a sufficient number of trained O/R's to operate both courses fully. Since interest was focused on the repeated two dashes, the lack of information from the other separate events of the Maneuver Course was unimportant.

The results of this additional testing with the weighted combat packs are shown in Table 3. It should be noted, as indicated at the top of the table, that the weight of the packs varied somewhat from those used in the earlier data. The total weights of the packs were 15, 30 and 45 pounds.[1] Shown in the table are the size of the samples, the average performance times under the indicated conditions, and the results of statistical tests for differences between conditions. In making the statistical tests, a one-tailed t-test based on the differences between the related data from each subject was used.

Table 3 shows that, for the second, third, and fourth dashes, the 30-pound pack resulted in significantly longer performance times than the 15-pound pack. The 45-pound pack resulted in a significantly longer performance time than the 30-pound pack for the second dash

[1] This change was instituted because a better distribution of weight in the pack and about the harness and belt could be effected if the minimum load condition was 15 pounds. The other total weights were consistent with the 15-pound increments used in the earlier weighted packs (i.e., 10-25-40 pounds).

Table 3. Additional Data with Weighted Combat Packs

1st and 2nd 50-Yard Dashes Preceded Maneuver Course Events
3rd and 4th 50-Yard Dashes Followed Maneuver Course Events

Data of 1-2 April 1964
15# Pack vs. 30# Pack; N = 10

Course Event	Average Performance (Secs.)		Difference, Pack B minus Pack A	Significance of Differences
	15# Pack	30# Pack		
1st 50-Yard Dash	9.70	10.23	0.53	N.S.
2nd 50-Yard Dash	11.74	[illegible]	1.49	*
3rd 50-Yard Dash	9.80	11.36	1.56	**
4th 50-Yard Dash	13.23	15.29	2.06	**

Data of 13-21 April 1964
30# Pack vs. 45# Pack; N = 16

Course Event	Average Performance (Secs.)		Difference, Pack C minus Pack B	Significance of Differences
	30# Pack	45# Pack		
1st 50-Yard Dash	12.73	13.61	0.88	N.S.
2nd 50-Yard Dash	14.61	15.79	1.18	*
3rd 50-Yard Dash	13.27	14.01	0.74	N.S.
4th 50-Yard Dash	16.46	17.32	0.86	N.S.

* = $p < .05$
** = $p < .01$

only. All other data were in the expected direction but were not significant. It might be noted that the data comparing the 15- and 30-pound packs show an increasing discrimination between the effects of the two packs with each additional 50-yard dash. A similar effect was not noted for the data comparing the 30- and 45-pound packs. Since the groups of subjects for the two sets of data presented in Table 3 are different, no composite comparison across the three packs was made.

VIII. Interpretation of Results

The following conclusions are made in reference to the results presented in the preceding section:

- The magnitudes of the differences detected as significant--primarily in reference to the weighted combat packs--are interpreted to indicate that, in general, the events comprising the Maneuver Course are all sensitive to a practically useful extent.

- The results obtained from the repetition of the two 50-yard dashes following the original experimental course are interpreted to indicate that this procedure will make the dash events more sensitive to the effects of personal clothing and equipment on performance. These results portend favorably for the Phase III integration of performance courses. The combination of individual courses into an integrated test regine in Phase III may result in greater course sensitivity than could be demonstrated during the Phase II research testing of individual courses.

IX. Recommendations for Final Test Course

Based upon all of the experiences gained in the tryout of the Phase II course, the following recommendations have merit for the design and operation of the Phase III Maneuver Course. The recommendations presuppose that the test setting will be similar to the Phase II course except where changes are specifically stated.

- The Phase III course should include as routine the additional two 50-yard dashes following the crawl event.

- Consideration should be given to replacing the A. W. Haydon stop clocks as the primary data collection

instrumentation. The nature of the problem lies in the fact that test personnel, despite practice, still made occasional errors in reading the clock dials. A safer alternative would be to have timing instruments which display elapsed time using a numeric or digital readout. Perhaps the best alternative would be to have two, centrally located, high resolution (milliseconds) timing devices which are capable of automatically printing out elapsed time plus indicating the source of the signal to print out. The needs of the Fire and Reload Weapon and the Maneuver Courses seem identical in this respect; hence, the feasibility of similar instrumentation for both courses should be studied. If feasible, the instrumentation from one course could serve as emergency backup for the instrumentation on the other course. Other advantages also seem possible if similar instrumentation can be used on more than one course; e.g., reduction in the variety of replacement or spare parts, printing paper and/or tape; reduction in maintenance training, etc.

Finally, consideration should be given to automating some of the event recording. We have in mind particularly arrival times at the end of each of the four dashes, the end of the obstacle course, and the end of the crawl course. One suggestion is to locate pressure-sensitive switches at the sandbags marking the ends of these events. As the course was operated during Phase II, O/R's were instructed to depress their response switch (O/R button) when the subject was both <u>prone and with his rifle at his shoulder</u>. The latter behavioral condition, while overt, does permit for intra- and inter-O/R variation. Furthermore, there is subject variation in the degree of "wriggling" and realigning of position associated with placing the rifle at the shoulder so as to simulate the execution of an aimed round. The latter variations--while normal and necessary to create a realistic test setting--are all essentially unwanted sources of variation when the primary interest is to measure performance effects in running, climbing, crawling, etc. Hence, the use of some automatic sensor to indicate arrival at a position may possibly refine the precision of performance measurement, as well as automate a portion of the data collection. The "start" signal for each event should still be an O/R function as well as the measurement of performance on the overhead ladder, the running jump, and the debarkation net events.

APPENDIX A

Troop Briefing
O/R Briefing

A-1

Maneuver Course

Troop Briefing

1. Purpose of the Course

You are serving in research experiments that will eventually lead to a standard course on which to evaluate the effects of Quartermaster clothing and equipment on a soldier's ability to perform important combat tasks. This is a serious and expensive undertaking. Everyone wants the American soldier to have the best clothing and equipment. The best clothing and equipment may save lives.

Today, and for the next few days, we will be evaluating our preliminary concepts for a course designed to reveal the effects of Quartermaster clothing and equipment on the infantry soldier's ability to maneuver as an individual, such as might be required when under fire.

2. Course Procedures

The course consists of seven events:[1]

- Two fifty-yard dashes
- An obstacle course
- An overhead ladder
- A running jump event
- A landing net climb
- A barbed-wire crawl
- Two fifty-yard dashes

You will each have an opportunity later to walk through the entire course, and we will demonstrate how you are to perform each event.

You will each run the course individually. The uniform for these trials will be the fatigue jacket, trousers, combat boots, and

[1] The initial testing of the Maneuver Course did not include the last two fifty-yard dashes and instructions omitted reference to these dashes.

fatigue hat. You will all carry the M-1 rifle. You may be issued special clothing or equipment prior to running the course. At the beginning of the course, you will start on signal from the Senior Controller. Thereafter, the observer/recorder at the end of the event which you have just completed will start you on the next event.

The order of events on the course is as already stated. The course starts with a fifty-yard dash. You will be in a prone position behind a log that marks the START of the course. On signal from the starter, you will get up and run the first fifty yards as quickly as possible and take a prone position with your rifle at your shoulder in the sandbag position which marks the end of the first dash. When signalled by the observer/recorder at the end of the first fifty-yard dash, you will then get up and run as quickly as possible over the next fifty yards taking a prone position with your rifle at your shoulder in the sandbag position which marks the end of the second fifty-yard dash. The observer/recorder at the end of the second fifty-yard dash event will tell you when to begin the obstacle course.

On the obstacle course, we are interested in how quickly you can run this event. As you will see later, the obstacles include two mazes, two scaling walls, a window-type obstacle, ground logs, a dirt mound, and some foot bridges. At the end of the obstacle course, you will move next to the overhead ladder. When told to START by the observer/recorder at the ladder, you will--in a hand-over-hand manner--traverse the ladder as quickly as possible. Next you will move to the running jump event.

The running jump event is not timed--we are interested in how far a running jump you can make. When signalled by the observer/recorder at the jump event, you will run from the starting line and jump as far as you can into the sand pit.

Next you will proceed to the landing net where, when signalled to "START" by the observer/recorder, you will climb up the landing net, cross over the tower, and come down the other side of the landing net. In this landing net event, we are interested in how quickly you can climb and descend the landing net.

Finally, when told to "GO" by the observer at the beginning of the barbed-wire crawl course, you will crawl under the barbed wire,

through the three-foot diameter pipe obstacle and again under the barbed wire to the sandbag fighting position which marks the end of the crawl event. You will put your rifle to your shoulder in a prone position as quickly as possible when you get to the end of the crawl event. At no time while you are on the crawl course will you stand up--you must traverse the entire course event by crawling. Again, we are interested in how quickly you can crawl under the barbed wire, through the pipe, and again under the barbed wire to the sandbag fighting position. (The high-low crawl procedure will be utilized.)

When you have completed the crawl event, the observer/recorder will direct you back to the starting point where you will repeat the first two fifty-yard dashes. This marks the end of the Maneuver Course.

As already mentioned, we will walk through the entire course and demonstrate how you are to perform on each event. Keep in mind that we are interested, in all cases except the jump event, in how quickly you can complete each of the test segments.

Are there any questions?

Maneuver Course

O/R Briefing

1. Purpose of the Course

The purpose of the Maneuver Course is to study the effects of Quartermaster clothing and protective equipment on the infantry soldier's ability to run, jump, climb and crawl (i.e., "maneuver"). This course, like the March/Move and Hasty Fighting Positions Courses, is one of a series of courses being developed to measure performance in the most important combat tasks of line infantry.

In this maneuver course, and as will be discussed more fully in a moment, we are primarily interested in two things: a) how quickly a soldier can complete (run) each of the course events; and b) how far a running jump a soldier can make.

2. Course Description and Use

Our present course is a preliminary one and, as most of you know, it is located around and uses several of the existing events in the obstacle course adjacent to the accelerated fabric wear courses. The course itself is made up of the following seven events in sequence:[1]

- Two fifty-yard dashes
- An obstacle course
- An overhead ladder
- A running jump event
- A landing net climb
- A barbed-wire crawl
- Two fifty-yard dashes

We'll all have an opportunity later to walk through the entire course. At that time, we'll review and/or demonstrate both how each event is to be performed and the duties of the O/R stationed at the event.

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[1] **See footnote, Page A-1.**

The following is a general overview of the course procedures and how test subjects will execute the course.

Each test subject will run the course individually. At the beginning of the course, the subject will start on signal from the starter. Thereafter, the observer/recorder at the end of each event will start the test subject on the next event.

The order of events on the course will be as already stated. The course starts with a fifty-yard dash. The test subject will be in a prone firing position behind a log that marks the START of the course. On signal from the starter, he will get up and run the first fifty yards as quickly as possible and take a prone position with his rifle at his shoulder in the sandbag position which marks the end of the first dash. When signalled by the observer/recorder at the end of the first fifty-yard dash, he will then get up and run as quickly as possible over the next fifty yards taking a prone position with his rifle at his shoulder in the sandbag position which marks the end of the second fifty-yard dash. The observer/recorder at the end of the second fifty-yard dash event will next tell him when to begin the obstacle course.

On the obstacle course, we are interested in how quickly the men can run this event. As we will see later, the obstacles include two mazes, two scaling walls, a window-type obstacle, a log mound and some foot bridges.

At the end of the obstacle course, the subject will move next to the overhead ladder. When told to "START" by the O/R at the ladder, he will--in a hand-over-hand manner--traverse the ladder as quickly as possible. Next he will move to the running jump event.

The running jump event is not timed--we are interested in how far a running jump the subject can make. When signalled by the O/R at the jump event, the subject will run from the starting line and jump as far as he can into the sand pit.

Next, the subject will proceed to the landing net where, when signalled to "START" by the O/R, he will climb up the landing net, cross over the tower and come down the other side of the landing

net. In this landing net event, we are interested in how quickly he can climb and descend the landing net.

Finally, when told to "GO" by the observer at the beginning of the barbed-wire crawl course, the subject will crawl under the barbed wire, through the three-foot diameter pipe obstacles and again under the barbed wire to the sandbag fighting position which marks the end of the crawl event. He will put his rifle at his shoulder in a prone position as quickly as possible when he gets to the end of the crawl event. At no time while he is on the crawl course may he stand up --he must traverse the entire course event by crawling. Again, we are interested in how quickly he can crawl under the barbed wire, through the pipe, and again under the barbed wire to the sandbag fighting position.

When the subject has completed the crawl event, he will be directed back to the starting point where he will repeat the first two fifty-yard dashes.

3. Observer/Recorder Procedures

An O/R will be stationed at, or at the end of, each event on the course. His primary duties will generally be six-fold:

a) He will stop his time clock, using a remote push button, at the instant the test subject completes his event.

b) He will next record on his data sheet the time indicated on the clock (i.e., the time required by the subject to complete the event to the nearest hundredth of a second).

c) He will also record in the remarks column of the data sheet any unusual occurrences, such as falls or other difficulties, encountered by the subject.

d) He will next alert the O/R at the end of the next event that he is about to start a subject.

e) He will then simultaneously tell the subject to "GO" and also press the push button starting the clock which is located at the end of the next event.

f) He will then reset his own time clock to "zero."

Let's take a look now at the location and detailed duties of all personnel.

Starter--Location: At Starting Point

a) Insure that each subject is wearing the proper uniform, i.e., fatigue shirt and trousers, hard cap and boots (no field jacket).

b) Insure that each subject is carrying an M-1 rifle.

c) Insure that each subject is wearing the proper equipment, e.g., Pack A, B, C, Mask, Gloves, etc., as specified by the test officer.

d) Insure that each subject starts from the Prone position and runs as rapidly as possible to the 1st sandbagged fighting position where he is to hit the prone position with the weapon at his shoulder.

e) Check with O/R No. 1 to insure his clock timer is reset and that he is ready to receive the subject. When such clearance is received:

1) Start the subject on the 1st fifty-yard dash.

2) Simultaneously start the clock timer by depressing the remoted button.

O/R No. 1--Location: End of First 50-Yard Dash Event

a) The starter will inform you when he is ready to send along the next subject. After you have checked to insure that your clock timer is reset, you are to give the starter clearance.

b) At the instant the subject arrives and takes cover at the sandbag position with his rifle at his shoulder, you are to

1) Stop the clock timer.

2) Record the time in the proper space on the data collection form.

3) Note and record any unusual events.

c) Inform O/R No. 2 that you are ready to send the subject on.

d) If all is clear:

1) Instruct the subject to run the next fifty yards as rapidly as possible and take cover with his rifle at his shoulder in the sandbag position at the end of the event.

2) Start the subject and press the button which starts the clock timer at the No. 2 position.

e) Reset the clock timer at your position.

O/R No. 2--Location: End of Second 50-Yard Dash Event

a) O/R No. 1 will inform you when he is ready to send along the next subject. After you have checked to insure that your clock timer is reset, you are to give O/R No. 1 clearance.

b) As soon as the subject arrives and takes cover with his rifle at his shoulder, you are to:

1) Stop the clock timer.

2) Record the time in the proper space on the data collection form.

3) Note and record any unusual events.

c) Inform O/R No. 3 that you are ready to send the subject on.

d) If all is clear:

1) Instruct the subject to run the obstacle course as rapidly as possible and take a prone position with his rifle at his shoulder at the sandbags at the end of the event.

2) Start the subject and press the button which starts the clock timer at the No. 3 position.

e) Reset the clock timer at your position.

O/R No. 3--Location: End of Obstacle Course

a) Your duties are the same as O/R No. 2.

b) Instead of starting your subject on the overhead ladder event, you will merely release your subject to O/R No. 4.

O/R No. 4--Location: Overhead Ladder

a) O/R No. 4 will both start and stop (and reset) his own clock timer.

b) After checking to be sure that your clock is reset:

1) Tell the subject to start traversing the ladder.

2) Simultaneously start the clock.

c) As soon as the subject's feet hit the ground at the end of the event (or if the subject cannot complete the event and drops to the ground):

1) Stop the clock timer.

2) Record the time in the proper space on the data collection form.

3) Note and record any unusual events.

d) If the subject did not complete the overhead ladder, be sure and record the number of the last rung which the subject reached.

e) You will then direct the subject to the starting line for the running jump event.

f) Reset the clock timer at your position.

O/R No. 5--Location: Beside the Sand Pit of the Jump Event

The jump is not a timed event. We are interested primarily in HOW FAR the test subject can jump.

a) From your position beside the sand pit, tell the subject to run and jump as far as he can into the pit, on your signal.

b) Then:

1) Signal the subject to jump.

2) Note and record the distance jumped to the nearest inch in the proper space on the data collection form.

3) Note and record any unusual events.

c) You will then direct the subject to O/R No. 6 at the starting position for the landing net climb event.

O/R No. 6--Location: Landing Net Climb Event

a) O/R No. 6 will both start and stop his own clock timer.

b) You will instruct the subject that when you tell him to start, he is to climb up the landing net, cross over the top of the tower, and descend the other side of the net.

c) Then, after checking to be sure that your clock is reset:

1) Tell the subject to start.

2) Simultaneously start the clock.

d) As soon as the subject's feet hit the ground on the other side of the net:

1) Stop the clock timer.

2) Record the time in the proper space on the data collection form.

3) Note and record any unusual occurrences.

e) You will then direct the subject to O/R No. 7 at the start of crawl course.

f) Reset the clock timer at your position.

O/R No. 7--Location: Start of Crawl Course

a) You will instruct the subject that he is to take a prone position behind the log that marks the start of the crawl course. You will further instruct him that when you say START, he is to crawl under the wire obstacles, through the pipes, and again under the wire obstacles as quickly as possible. At the end of the event, he is to take a prone position with his rifle at his shoulder behind the sandbags that mark the end of the course. Remind the subject that:

1) He must not stand up at any time.

2) He is to roll over the log obstacles.

b) Performance will be measured by means of a stopwatch. After checking to insure that your stopwatch is reset and in proper working order:

1) Tell the subject to start.

2) Simultaneously start the stopwatch.

c) As soon as the subject arrives at the sandbags and puts his rifle at his shoulder, you are to:

1) Stop the stopwatch.

2) Record the time in the proper space on the data collection form.

3) Note and record any unusual occurrences.

d) Direct the subject to immediately return to the Starting Point.

e) Reset the stopwatch.

Starter: At Start of First 50-Yard Dash[1]

a) Immediately upon a subject's arrival back at the starting point, repeat the 1st and 2nd fifty-yard dash events as described above.

b) Insure that O/R No. 2 (located at end of 2nd fifty-yard dash) is informed to instruct the subject to return to the starting point at the finish of his event.

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[1]See footnote, Page A-1.

APPENDIX B

Instrumentation Description
Wiring and Pictorial Diagrams

Maneuver Course

Timing System

A. Operation

The following description pertains to the wiring and pictorial diagrams shown in Figures 27 and 28.

Assume that an event (the beginning and end of which may be observed from Locations "A" and "B", respectively) is to be timed and that the clock has been "reset"; i.e., the hands of the clock are stationary and the indicated elapsed time is zero.

The operator at Location "A" momentarily actuates (one to two seconds will suffice) Switch S1 (the "START" Switch) so as to coincide with the beginning of the event. The momentary actuation of Switch S1 causes Relay K1 to be energized. A holding-contact (on Relay K1) has been provided to keep Relay K1 energized after Switch S1 has been released. The clock commences when Relay K1 has been energized. Thus, the event is under way and the clock is measuring the elapsed time of the event.

The operator at Location "B" (situated so as to be able to observe the end of the event) momentarily actuates Switch S2 (the "STOP" Switch) so as to coincide with the end of the event. Relay K1 is de-energized--causing the clock to stop--and remains de-energized after Switch S2 is released because both Switch S1 and the holding-contact on Relay K1 are open. After recording the elapsed time, the operator at Location "B" may reset the clock by momentarily actuating Switch S3 (the "RESET" Switch).

B. Assembly of Timing System

The electrical wiring diagram for the timing system is shown in Figure 27. The basic components are: three switches; one relay; the clock mechanism; and two line plugs to connect the system to 110 volt, 60 cycle power lines. A pictorial diagram of the system indicating the interconnections between the various components is shown in Figure 28.

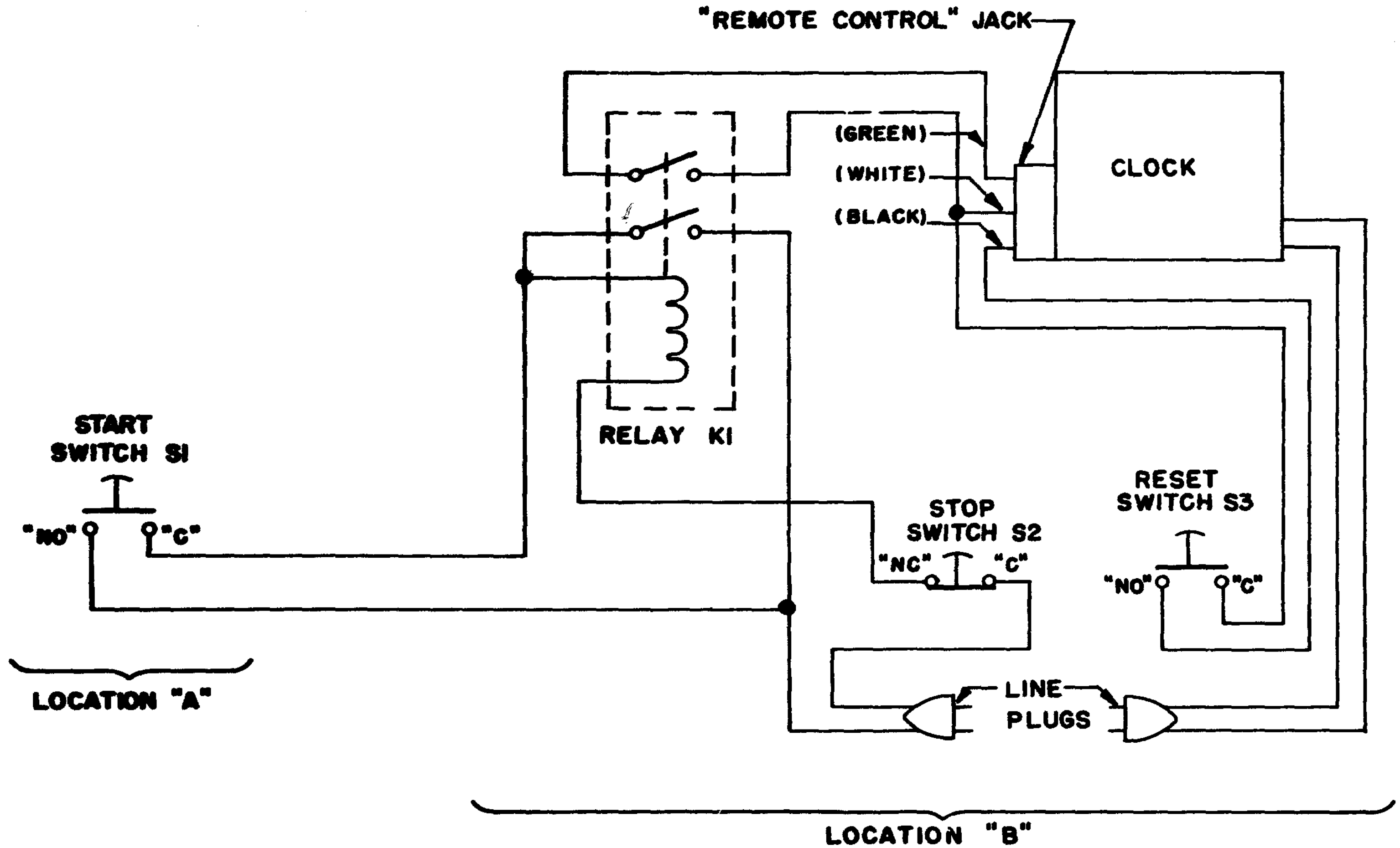

Figure 27. Wiring Diagram.

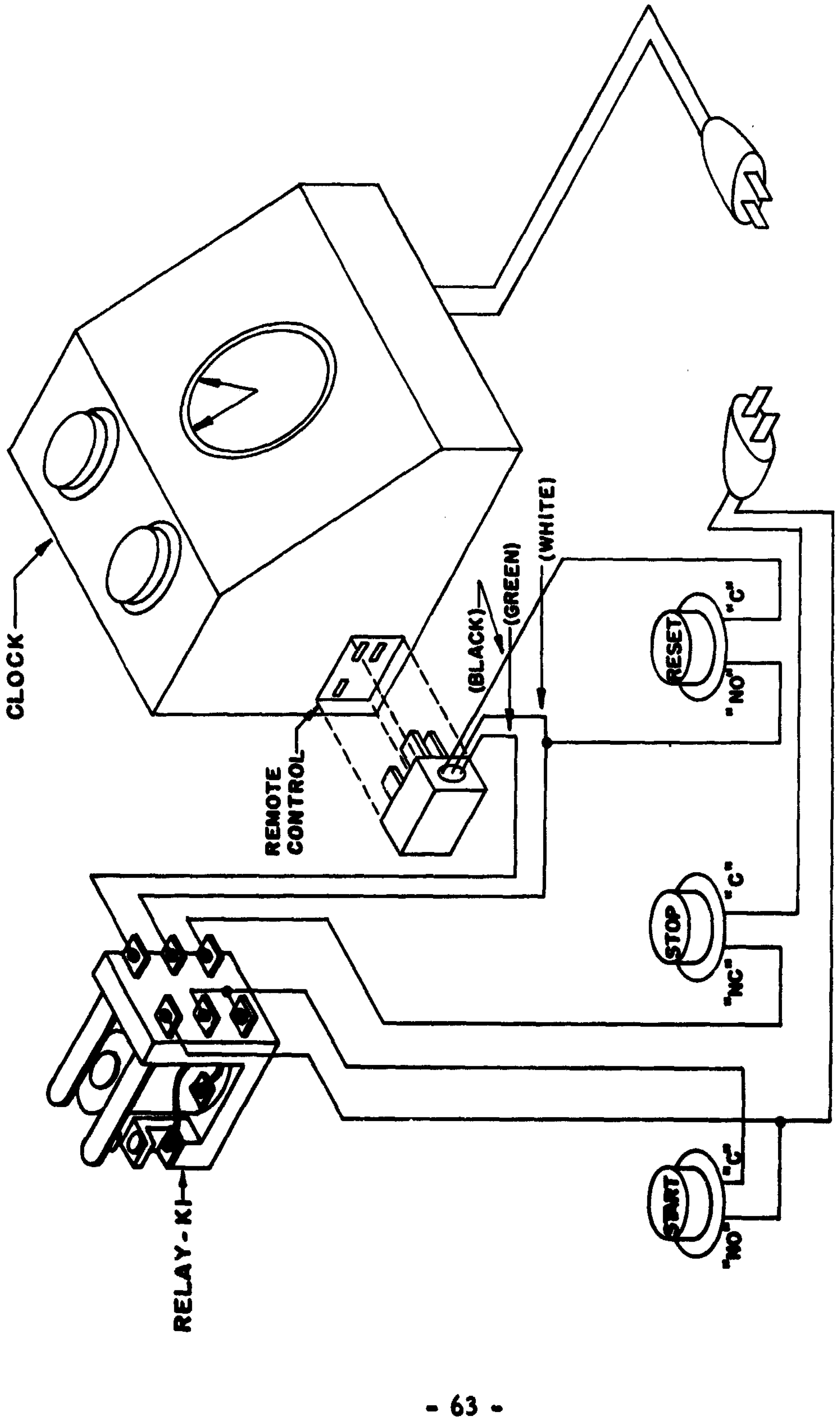

Figure 28. Pictorial Diagram.

1. Switches

A switch which can be connected either as a normally-open momentary or a normally-closed momentary type has been selected for use in this system. To wire Switch S1, only the terminals marked "NO" and "C" (which represent "normally open" and "common," respectively) are connected. The remaining terminals on Switch S1 will not be used. Switch S3 will be wired in the same manner (using another switch) as Switch S1. As shown in Figures 27 and 28, a normally-closed momentary switch is required for Switch S2. As before, the same basic switch type will be used; this time, however, the terminals marked "NC" and "C" (which represent "normally closed" and "common," respectively) will be connected. The recommended hookup wire is 16 gauge rubber-covered line cord.

Some means of enclosing the switches so they may be hand-held must be provided. A suggested method is to insulate the exposed switch terminals with electrical tape and then mount the switch (via the threaded shaft, nut, and lock-washer) in a cylindrical brass or aluminum tube about two inches long and one inch in diameter.

2. Relay

The "Parts Description" section contains a list of several relays suitable for use in this system. Shown in Figure 28 is a relay with two pairs of normally-open contacts (DPST, normally-open). If such a relay is not readily available, an equivalent relay may be obtained by making appropriate connections to a double-pole, double-throw (DPDT) relay. This may be done by examining the DPDT relay to determine which terminals are associated with the normally-open contacts.

3. "Remote Control" Connector

A length of three-conductor cable with a plug designed to fit into the "Remote Control" socket on the clock chassis is available from the manufacturer of the timing clock. The location of the "Remote Control" socket in the timing clock chassis is shown in Figure 28. The conductors are color-coded and can be readily identified.

C. Parts Description

1. Switches

- Switch S1: Honeywell Microswitch Type 2PB238. This is a DPDT momentary switch which will be connected as a momentary SPST switch. A 3/4-inch diameter, 3/8-inch high plastic button for use with the above switch is available from Honeywell.
- Switch S2: Same as Switch S1
- Switch S3: Same as Switch S1

2. Relay

Relay K1 can be any conventional 110V AC relay with two pairs of normally-open contacts. A 110V AC DPDT relay can be used in this application if properly connected. (See discussion under "Relay" heading in the "Assembly of Timing System.")

Relays suitable for this application are:

- Guardian, Series 2210 DPDT (normally-open) coil voltage: 115V AC. Cost: Approximately $5.25 each.
- Guardian Type IR-500-G115, DPDT Cost: approximately $3.10 each.
- Guardian Type 1200-G115, DPDT Cost: approximately $3.60 each.
- Potter and Brumfield Type AB11AY, DPDT, coil voltage: 115V AC. Cost: approximately $5.30 each.
- Potter and Brumfield Type KA11AY, DPDT, coil voltage: 115V AC. Cost: approximately $3.85 each.
- Potter and Brumfield Type MR11A, DPDT, coil voltage: 115V AC. Cost: approximately $4.85 each.

APPENDIX C

Additional Data

Table 4. Results by Replications of the Vest vs. No Vest Comparison

Data of 19-29 August 1963

(Collected Using Preliminary Instrumentation of PRC-6's)

Data Consist of 4 Replications of Course Under Vest vs. No Vest Test Conditions

Course Event	N	Average Performance (Secs.) Vest	No Vest	Test for Significant Differences
1st 50-Yard Dash				
Rep. 1	7	10.7	10.9	N.S.
2	8	13.3	11.7	N.S.
3	10	11.7	11.3	N.S.
4	10	11.8	11.2	N.S.
2nd 50-Yard Dash	7	12.7	13.3	N.S.
Rep. 1	8	16.8	15.3	N.S.
2	10	14.8	13.4	*
3	10	14.8	14.1	N.S.
Obstacle Course				
Rep. 1	6	123.1	116.4	N.S.
2	8	126.9	135.8	N.S.
3	8	116.0	133.8	N.S.
4	10	119.8	121.0	N.S.
Overhead Ladder				
Rep. 1	5	7.6	8.1	N.S.
2	4	7.1	6.4	--(No Test)
3	8	6.5	5.7	N.S.
4	10	5.7	5.2	N.S.
Landing Net				
Rep. 1	7	63.6	50.4	*
2	8	60.1	59.2	N.S.
3	9	44.4	49.1	N.S.
4	9	54.9	46.9	*

* = Statistically Significant Difference, $p < .05$

Table 4. Results by Replications of the Vest vs. No Vest Comparison (Continued)

Data of 19-29 August 1963

(Collected Using Preliminary Instrumentation of PRC-6's)

Course Event	N	Average Performance (Secs.)		Test for Significant Differences
		Vest	No Vest	
Crawl Course				
Rep. 1	7	210.7	224.6	N.S.
2	8	197.5	214.2	N.S.
3	7	219.4	232.7	N.S.
4	10	242.0	220.0	N.S.
Running Jump (Ft.)				
Rep. 1	4	10.1	10.8	--(No Test)
2	8	10.7	10.2	N.S.
3	9	11.3	11.7	N.S.
4	10	11.1	11.4	N.S.

* = Statistically Significant Difference, $p < .05$

APPENDIX D

Project Reports

D-1

PROJECT REPORTS

I. Report of Phase I, USATECOM Project No. 8-3-7700-01, Development of a Methodology for Measuring Effects of Personal Clothing and Equipment on Combat Effectiveness of the Individual Field Soldier, U.S. Army QM R&E Field Evaluation Agency (now U.S. Army General Equipment Test Activity), February 1964.

II. Reports of Phase II, USATECOM Project No. 8-3-7700-01, Development of Methodology for Measuring Effects of Personal Clothing and Equipment on Combat Effectiveness of Individual Soldiers, (U.S. Army General Equipment Test Activity):

1. Identification of Important Tasks of Combat Infantry - Report of Results from a Further Refinement, November 1964.
2. Development of a Methodology for Measuring Infantry Performance in Rifle Firing and Reloading, June 1965.
3. Development of a Methodology for Measuring Infantry Performance in Maneuverability, June 1965.
4. Development of a Methodology for Measuring Infantry Performance in Marching and Moving, June 1965.
5. Development of a Methodology for Measuring Infantry Performance in Grenade Throwing, June 1965.
6. Development of a Methodology for Measuring Infantry Performance in Digging Hasty Fighting Positions, June 1965.
7. Final Report, Phase II, December 1964.

AD Accession No.

U. S. Army General Equipment Test Activity, Fort Lee, Virginia

DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN MANEUVERABILITY, THIRD PARTIAL REPORT OF USATECOM PROJECT NO. 8-3-7700-01, PHASE II, DEVELOPMENT OF METHODOLOGY FOR MEASURING EFFECTS OF PERSONAL CLOTHING AND EQUIPMENT ON COMBAT EFFECTIVENESS OF INDIVIDUAL SOLDIERS, by A. Gruber, J. Wm. Dunlap, G. DeNittis, Dunlap and Associates, Inc., Darien, Connecticut, and J. L. Sanders, V. W. Perry, B. D. Dixon, U. S. A. General Equipment Test Activity, Fort Lee, Virginia, June 1965, 75 p., 4 Tables, 28 Figures. (TECOM 8-3-7700-01) Unclassified Report

A three-phase research effort is underway to develop field methodology for measuring the effects of experimental clothing and equipment on the combat effectiveness of individual infantrymen. This report covers a portion of the work performed under Contract DA 19-129-QM-2068 (OI 6141) by Dunlap and Associates, Inc., and is the third of a series of seven reports presenting the results of Phase II of the study.

The first partial report in this series reported work performed to identify and rank the relative importance of the physical tasks performed in combat by the individual infantryman. One of the

UNCLASSIFIED

1. Infantry combat tasks
2. Combat Effectiveness
3. Clothing--Effects
4. Protective equipment--Effects
5. Human engineering
6. Measurement methodology
I. Gruber, A.
II. Dunlap, J. Wm.
III. DeNittis, G.
IV. Sanders, J. L.
V. Perry, V. W.
VI. Dixon, B. D.
VII. Title
VIII. TECOM Project No. 8-3-7700-01 (Contract DA 19-129-QM-2068)

AD Accession No.

U. S. Army General Equipment Test Activity, Fort Lee, Virginia

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